7. Location Technologies

A number of technologies to locate cellular subscribers were presented. Approaches ranged from equipment placed at the cell site (requiring little or no changes to the mobile station) to autonomous position determination equipment placed in the mobile station. The executive summary of a report commissioned by APCO was submitted. The APCO report contained synopses of 17 methods and products to determine position.

8. Contributions

The following documents were contributed to the meeting. (Documents were numbered with a TR45.ESJEM/94.08. prefix. The prefix is abbreviated as # within this report.)

No.	Description	Source
.01.01	Agenda & Work Plan	Chair
.01.02	Emergency Services Planning Meeting Report	Chair
.01.03	Mobility Tutorial	Cheryl Blum - AT&T
.01.04	TIA JEM in Support of 9-1-1 and E-9-1-1 Emergency Services: E9-1-1 Tutorial	Peter Reed - NENA
.01.05	Industry Practices	P J Louis - Bellcore
.01.06	Tutorial on Emergency Services for Wireless Cellular	Kirk Carlson - Synacom
.01.07	Evolutionary Path	Jeff Crollick - GTE TSI
.01.08	TR45.2 Recommendation	Jeff Crollick - GTE TSI
.01.09	Wireless ANI/ALI	Smith Advanced Technology
.01.10	A Report to NENA, APCO & TIA Regarding Automatic Location Identification Requirements of PSAPs	Michael Celeski
.01.11	Public 800 Mobile and PCS Support of 9-1-1 and E9-1-1 Emergency Services	Alison Brown - NAVSYS Corp.
.01.12	Effects of Wireless Communications and Advanced Technology on Enhanced 9-1-1 Systems	Joe Blaschka - Adcomm Engineering Co.
.01.13	AT&T Public Safety Systems 911 Data Network Solution	Larry Ciesla, Mike Meyer, and Carolyn Robins - AT&T
.01.14	AT&T Public Safety Systems Common Channel Signalling Network Solution	Larry Ciesla, Mike Meyer, and Carolyn Robins - AT&T
.01.15	Survey of Location Technologies to Support Mobile 9-1-1	Clem Driscoll - C.J. Driscoll & Assoc.
.01.16	JEM Planning Meeting Contributions	Planning Meeting
.01.17	An Approach to Locating Wireless Transmitters For Public Safety	Louis Stilp - Associated Communications Corp.
.01.18	SS7 Data Elements from Mobile/PCS Provider	Joe Blaschka - Adcomm Engineering Co.
.03.01	PCIA, APCO, NENA, NASNA Emergency Access Position Paper	PCIA
.03.02	An Overview of the PINS System and its Application for Use in Determining the Position of Cellular Equipment Users	D. Kelley - Terrapin Corp.

9. Participants

Name	Organization	Phone
Bissonnette, Jane	McCaw Cellular	206-828-8005
Blaschka, Jr., Joe	Adcomm Engineering Co.	206-821-8827
Blum, Cheryl	AT&T	708-713-1449
Blust, Stephen	BellSouth Wireless, Inc.	404-249-5058
Bojeryd, Nils	Ericsson North America	214-997-0363
Bolen, Richard	USWest NewVector Group	206-450-8421
Boyd, Mary	Advisory Commission on State Emergency Communications	512-327-1911
Bradshaw, Thera	National Emergency Number Association	206-737-1911
Brown, Alison	NAVSYS Corporation	719-481-4877
Brush, Jr., Leonard	National Communication System	703-692-0175
Buchholtz, Bill	Bexar Metro	210-366-3911
Camp, John	SouthwesternBell Telephone	214-464-4863
Carlson, Kirk	Synacom Technology	408-296-0303
Carlson, Steven	Northern Telecom BNR	919-991-7352
Celeski, Michael	Pertech America, Inc.	708-425-7292
Celli, Philip	GTE Government Information Services	813-273-4702
Chen, Ben-Ren	GTE Laboratories	617-466-2141
Chiang, John	GTE Mobilnet	404-804-3573
Ciesla, Lawrence	AT&T	708-224-6747
Coe, Gerry	USWest Communications	303-896-8308
Croan, Butch	OneComm	303-721-2143
Crollick, Jeff	GTE Telecommunication Services	813-273-4776
Damm, Lennart	Ericsson Radio System AB	+468-757-0208
Diamond, Mitchell	GTE Personal Communication Services	404-804-3762
Ewart, Ben	Ericsson Radio Systems, Inc.	214-952-8743
Goldstein, Richard	Associated Communications Corporation	716-854-5076
Gorzocoski, David	Northern Telecom	214-684-5473
Gove, Richard	Ameritech	708-765-5872
Haakinson, Eldon	Institute for Telecommunication Sciences National Telecommunication and Information Administration	303-497-5308
Hall, Ed	Cellular Telecommunications Industry Association	202-736-3259
Halliburton, Huel	AirTouch Communications	510-210-3666
Henry, Kathy	OneComm	303-721-2204
Huml, Kathy	AT&T	708-224-6391
Isaac, Jennifer	QUALCOMM, Inc.	619-658-3780
Ishman, Chuck	Motorola	708-632-7921
Jacobson, Terry	AT&T	708-713-1665
Jones, Stephen	NEC America	214-518-5016
Keim, Ken	Oregon Department of State Police	503-378-2911
Kelley, David	Terrapin Corporation	714-898-8200
Kemper, Rick	Sprint Cellular	312-399-5177
Kent, Edward	NAVSYS Corporation	714-957-9350

Name	Organization	Phone
Kiljan, John	State of Colorado Department of Transportation	303-757-9508
Leung, Yiuman	Northern Telecom, Inc.	214-684-1004
Liebner, Lisa	GTE Information Services Inc.	813-273-4791
Louis, P. J.	Bellcore	201-740-4595
Lucy, Mike	Smith Advanced Technology, Inc.	601-264-2911
Marinho, John	AT&T	201-386-2886
McGrath-Hadwen, Eileen	Coral Systems, Inc.	303-772-5800
Meer, Stephen	SCC	303-581-5604
Meyer, Michael	AT&T	708-224-7382
Morrison, Lori	Advisory Commission on State Emergency Communications	512-327-1911
Nanke, Nancy	AT&T	708-713-1446
Potts, Hunter	GTE Government Information Services	813-273-4727
Proctor, Steven	Association of Public-Safety Communications Officials International, Inc.	801-538-3525
Reed, Peter	Pacific Bell	510-823-2711
Robins, Carolyn	AT&T	708-224-4453
Rose, Connie	Booz, Allen & Hamilton, Inc.	214-539-0044
Russell, Russ	GTE Telephone Operations	214-718-7911
Siviter, Jeremy	Castle Rock Consultants	703-771-0020
Smith, Alan	Lockheed-Sanders	603-885-2304
Stanton, William	National Emergency Number Association	614-622-8911
Stilp, Louis	Associated Communications Corporation	610-660-4910
Stoffels, Paul	Ameritech	312-727-2092
Vallier, Jacque	Ameritech Cellular Services	708-765-5813
Weigand, John	Motorola	708-576-2951
White, Ken	USWest Communications	303-965-0068
Yu, Chris	MCI	214-918-6249
Zan, W. K. (Watson)	Rogers Cantel	416-250-4365

10. Recommendations

TR45.2

Study and develop standards for the interfaces and wireless system operations described.

Use the term PSAP (Public Safety Answering Point) instead of ESAP (Emergency Service Access Point) for future documents.

TR45.1, TR45.3, TR45.4, TR45.5

Study Mobile Station enhancements described and the air interface issues raised, including, but not limited to:

- Mobile Stations should allow [9]-[1]-[1]-[SEND] to be dialed at all times (even when locked or when served by a restricted system).
- Future 800 MHz air interface standards should support the Priority Access and Channel Assignment feature defined in PN-2977 (the proposed IS-53A Cellular Feature Descriptions).
- Silent callback feature allowing a specialized Mobile Station to not alert audibly and to automatically answer under air interface control.
- New Mobile Stations that utilize Identity Modules may be able to initiate 9-1-1 calls if the Identity Module is not present.

Numbering Plan Organizations

Consider a non-dialable national office code for PSAPs. (This could be 911 to allow directory numbers in the form: NPA-911-XXXX) This office code can be used to route inter-LATA (Local Access and Transport Area) calls through an Access Tandem to a specific PSAP. It can also be used to identify emergency service callback calls to bypass subscriber features (such as, call forward, do not disturb, etc.).

Other Organizations

Forward the JEM Report to other interested organizations for their consideration.

PRESIDENT
STEVEN H. PROCTOR

Information Technology Services
6000 State Office Bldg.
Salt Lake City, UT 84114

(801) 538-3525 - Fax: (801) 538-3321
Voice Mailbox: (800) 949-APCO Ext. 403

ASSOCIATION OF PUBLIC-SAFETY COMMUNICATIONS OFFICIALS INTERNATIONAL, INC.

EXECUTIVE DIRECTOR
JAMES R. RAND

APCO International Headquarters
2040 S. Ridgewood Ave.
South Daytona, FL 32119-8437

(904) 322-2500 or (800) 949-APCO Ext. 222
Fax: (904) 322-2501

August 30, 1994

Dr. Thomas Stanley
Chief Engineer
Office of Engineering and Technology
Federal Communications Commission
2025 M Street NW Room 7002
Washington DC 20554

Dear Dr. Stanley:

Attached for your consideration is a copy of a "Survey of Location Technologies to Support Mobile 9-1-1," conducted by C.J. Driscoll & Associates for APCO and the State of California, Department of General Services Telecommunications Division. We hope that this information will be useful in the Commission's preparation of its Notice of Proposed Rulemaking regarding Enhanced 9-1-1 systems and wireless telephone services. The study is part of the Project 31 process currently undertaken by APCO.

Please contact me if you have any questions, or need additional information at this time.

Sincerely,

Steven H. Proctor
President

c: Jules Knapp
Richard Engelman
David Wilson

SURVEY OF LOCATION TECHNOLOGIES

TO SUPPORT MOBILE 9-1-1

Survey Conducted for State of California Department of General Services Telecommunications Division, Sacramento, California and for the Association of Public Safety Communications Officials (APCO)

Edition 1.0

JULY, 1994

C.J. DRISCOLL & ASSOCIATES

2066 Dorado Drive
Rancho Palos Verdes, CA 90275
Telephone: (310) 832-8834
Fax: (310) 832-3468

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C.J. DRISCOLL & ASSOCIATES

C.J. Driscoll & Associates, based in Rancho Palos Verdes, California, provides consulting services on automatic vehicle location and mobile communications to fleets and industry suppliers. Clients include major cellular operating companies, Fortune 100 electronics manufacturers, venture capital start-up companies and government agencies.

Clement Driscoll, principal of C.J. Driscoll & Associates, has over 15 years of experience in the fields of navigation, radiolocation and mobile communications. Mr. Driscoll formerly directed the marketing of PacTel Teletrac's fleet vehicle location system. He also served as Product Line Manager for Magnavox's commercial GPS and satellite communication products. Mr. Driscoll has conducted numerous proprietary studies for client companies and has written articles on vehicle location and mobile communications for publications including *Automotive Fleet*, *GPS World* and *Communications* magazines.

INTRODUCTION

Purpose of the Study

The purpose of this study is to identify location technologies which could be deployed to provide 9-1-1 response organizations with the capability to locate a caller using a wireless phone to request emergency assistance. Presently, wireless 9-1-1 calls do not have caller location information, precluding the intelligent routing of the call to the proper response agency. Many wireless callers are not aware of their location and the emergency situation adds to their disorientation. This lack of information extends the call interrogation process and delays the dispatch of the appropriate response agency.

Scope of the Study

This report identifies location systems and technologies which could be applied to mobile 9-1-1. The author believes that the systems covered in this study are representative of the state of the technology, though it is unlikely that all systems capable of locating mobile 9-1-1 callers have been covered. The study only covers systems developed by U.S. suppliers.

As the purpose of this study is to address the feasibility of automatically locating mobile 9-1-1 callers using cellular, PCS or ESMR networks, the study does not attempt to cover systems which utilize a vehicle mounted or handheld device other than a mobile phone to request police or medical assistance. However, it is appropriate to note that a number of companies are expected to offer systems in configurations other than mobile phones for requesting emergency assistance. It is anticipated that a number of vehicle-mounted systems will use GPS for location.

Organization

This report is divided into two sections. The first section covers systems which compute the location of the caller using signals transmitted over the network on which the call was placed. A number of these systems require an overlay to the wireless network. Other systems require a modification to the software or hardware in the phone. This section also covers several companies which have radiolocation technologies that could be applied to locating mobile 9-1-1 callers, but which are not currently developing a system targeted at this application.

The second section covers location systems which rely on an external network or infrastructure to compute location. These systems either use an existing network or infrastucture to compute location or compute position based on a proprietary network of antennas deployed around a metropolitan area. These systems require either that a

receiver module be embedded in the wireless phone or that an external module be interfaced to the phone. Some of these systems use the Global Positioning System (GPS) to compute location and one system makes use of the existing commercial FM radio infrastructure.

TERMINOLOGY

AVM: Acronym for Automatic Vehicle Monitoring. Systems such as AirTouch Teletrac which operate in the 902-928 MHz band and offer subscription-based vehicle location and data messaging services in metropolitan areas. See p. 53 for further explanation.

CDMA: Acronym for Code Division Multiple Access. Wireless voice transmissions are encoded and spread across a broad band of spectrum. Each transmission is assigned a unique code and only be identified and retrieved by the designated receiver. This allows more calls to occupy the same space in a communications channel. Qualcomm, Inc. is a primary developer of CDMA technology for use in wireless networks. CDMA modulation is expected to become one of the standards for digital cellular and Personal Communications Services (PCS) networks.

CDPD: CDPD is an acronym for Cellular Digital Packet Data, which is a system for transmitting data files over idle channels of existing cellular voice networks. A consortium of cellular operating companies will implement this service on their networks beginning in 1994.

DOA: Stands for Direction of Arrival. Location systems based on this technology generally use multiple array antennas, which allow for calculation of the angle of arrival of signals from wireless phones. The location of the transmitting device is the intersection point of lines of position based on DOA measurements at a minimum of two base stations.

ESMR: Acronym for Enhanced Specialized Mobile Radio. These are digital subscription-based two-way radio networks. These digital networks, being deployed by companies such as Nextel Communications, will be targeted at both commercial fleet and consumer markets and will compete with cellular and PCS.

GPS: Stands for Global Positioning System. This is a satellite navigation system deployed by the U.S. military, but widely used for commercial and civil applications. The GPS constellation consists of 24 satellites (21 primary satellites and 3 spares) in six orbital planes at an altitude of 10,900 nautical miles above the earth. The GPS satellites continuously transmit precisely timed signals which include information that enables GPS receivers to accurately determine the satellite's position in orbit. Since the signals travel at the speed of light, the amount of time that elapses from transmission to receipt of the satellite signal is easily converted by the receiver to the range or distance to the satellite. Range measurements to four or more satellites are generally needed for a receiver to compute location, but three satellites are sufficient if the altitude of the receiver above sea level is fairly constant. For security reasons, GPS accuracy is intentionally degraded by the U.S. government to 100 meters (95% probability). Average accuracy is actually about 50 meters.

ISM: Acronym for Industrial, Scientific, Medical band. The 902-928 MHz frequency band is often referred to as the ISM band, as the Federal Communications Commission authorizes certain types of equipment in these categories (including welding, sealing, diathermy, etc.) to operate in this band. This band is also shared by Automatic Vehicle Monitoring (AVM) systems, government users, automatic vehicle identification systems, unlicensed users employing low-powered spread spectrum equipment (Part 15 of FCC rules) and amateur users.

IVHS: Stands for Intelligent Vehicle Highway Systems. This is a government sponsored initiative to encourage technology developments to improve the flow of traffic on U.S. roads and highways. IVHS technologies include Automatic Traffic Information Systems to advise drivers of traffic congestion and alternate routes, Automatic Traffic Management Systems for improved municipal traffic flow management and other technologies. It is hoped that these technologies will reduce traffic delays, reduce pollution and increase safety.

MTSO: Short for Mobile Telephone Switching Office. This is the central computerized switch that controls the cellular network.

Multipath: Reception of a signal taking more than one path, one of them being a path directly from the transmitter, the others being paths caused by signal reflections from objects.

PCS: Acronym for Personal Communications Services. This refers to wireless digital services which will let users make calls using low cost, lightweight pocket phones. PCS systems will be based on microcells, typically spaced every few blocks. Many PCS networks will operate in the 1.8 GHz band.

Spread Spectrum: A method of transmission in which the transmitted signal is spread over a much wider bandwidth than it would occupy with normal modulation.

TDOA: Acronym for Time-Difference-of-Arrival. This technique is widely used in radiolocation systems. It involves measuring the differences between the arrival times of the signal at different receivers (base stations). The path that would be followed by a vehicle traveling in a manner that maintains a constant time-of-arrival difference between any pair of base station receivers is a hyperbola. The transmitter (e.g. cellular phone) is located at the point of intersection of three hyperbolas based on time of arrival difference measurements at three base stations.

EXECUTIVE SUMMARY

SUMMARY OF LOCATION SYSTEMS AND TECHNOLOGIES FOR MOBILE 9-1-1

Network-based Location Systems

- **KSI, Inc.** has developed and patented the Direction Finding Localization System (DFLS) which computes the location of a wireless phone by measuring the angle of arrival of control or voice channel transmissions from the phone. KSI claims to measure angle of arrival at base stations with typical accuracy of .3 degrees, resulting in location accuracy of approximately 150 ft. Estimated cost to deploy DFLS is $30,000 per site for a basic system and $3-5 million per network. The company is working on an Enhanced Direction Finding System (EDFS) with a target cost of less than $30,000 per site.

- **Associated Communications Corporation** has developed a cellular location system which computes the location of the caller using Time-Difference-of-Arrival (TDOA) measurements on control channel transmissions from the phone. The company claims typical accuracy of 500 ft. or better, based on tests and demonstrations conducted on a Rochester, New York cellular network. This patented system will be ready for commercial deployment within 18 months through alliances with wireless network operators.

- **Engineering Research Associates (ERA)**, a subsidiary of E-Systems, has developed and patented the E-CAPS system which computes the location of a wireless phone using a combination of phase-based direction finding and TDOA techniques. ERA claims that location accuracy of E-CAPS is approximately 100 meters. E-CAPS performance will be evaluated in a Federal Highway Administration sponsored operational test to be conducted in Washington, D.C., beginning in October, 1994.

- **TrackMobile, Inc.** has patented a technique for computing the location of a cellular caller using signal strength measurements of control channel transmissions from A and B side cellular base stations. The signal strength measurements are transmitted from the phone to TrackMobile's Help Express Service Center where the caller's location is computed and passed to the responsible PSAP. The company reports typical location accuracy of 500 ft. A portable radio direction finding device is used in close range of the phone to determine its exact location. The TrackMobile system requires a modification to the software in the wireless phone, but no modification to the network.

- **U.S. West New Vector Group** is currently testing a system for locating a caller using a wireless network. The system uses Time-of-Arrival multilateration techniques to compute location. Simulation tests indicate a theoretical accuracy of 100 ft. Field tests of the system are currently underway. This system requires the addition of an

integrated circuit and software in the phone (estimated cost of $3) and a network overlay which may be achievable at a cost of $1/2 million for a typical network.

- **Lockheed Sanders, Inc.** has developed a cellular location system which the company states is suitable for use in a high multipath urban environment. The system requires the installation of a receiver and processor at cell sites. A proprietary TDOA technique is used to compute the approximate location of the caller. A handheld device is used in close range to determine the exact location of the caller. The company expects the system to be ready for commercial deployment in 1995.

- **Lattice Corporation** is a start-up company which is designing a system for locating wireless network callers based on an overlay to the wireless network. The company reports that the system is designed to be low cost and to be effective in mitigating the effects of multipath propagation. At this time, the company does not wish to discuss the technique used to compute location except under non-disclosure. It is anticipated that the system will be available for commercial deployment in 1996.

- **Cartesia Corporation** will be testing a low cost system it has developed for locating wireless callers which receives and processes control channel transmissions installed at each network cell site. The system is not yet patented and the technique for computing location was not disclosed. The company will conduct field trails in the second half of 1994 to determine system accuracy.

Network-based Location Technologies

- **Qualcomm, Inc.** reports that its Code Division Multiple Access (CDMA) technology for wireless networks could be used to compute the location of the caller. The company reports that precise time is available at CDMA base stations, and the spread spectrum transmissions are very similar to GPS. However, when a CDMA phone approaches a base station it becomes difficult to obtain an adequate signal-to-noise ratio on neighboring base stations, as necessary for triangulation. Qualcomm reports that there are several possible solutions to this problem, but limited work has been done in this area to date, as there has been little customer interest.

- **ESL, Inc.**, a subsidiary of TRW, reports that based on the company's extensive experience in the development of radiolocation products, they believe there are enough mature technologies in the marketplace that a practical and affordable wireless 9-1-1 system is well within reach. For mobile 9-1-1 location, the company recommends the use of GPS embedded in the mobile phone along with a cellular-based location system incorporating direction finding and TDOA technology. ESL states that requiring that GPS receivers be installed in mobile phones will bring the cost of GPS receivers down to a few dollars per unit. A cellular-based location system based on DF and TDOA could achieve accuracies of 100-300 ft.

- **ArrayComm, Inc.** has developed a system for enhancing wireless network communication quality and capacity, using Spatial Division Multiple Access (SDMA) technology. The company reports that determining the direction of arrival of signals from a mobile phone is fundamental to their technology. The accurate bearing information would reportedly make it possible to compute the location of the caller with an accuracy of +/- 50 ft. in open areas and with a lesser degree of accuracy in dense urban environments.

- **OAR Corporation** indicates that their direction finding technology can be applied to locating mobile callers. The company reports that an antenna array, bearing processor and receiver could be installed at a cell site for $10,000 or less, yielding bearing accuracy of approximately 3 degrees. In an urban environment, typical location accuracy would be within a city block.

- **Scientific Research Laboratories, Inc.** has developed a system called SpecTrack which is used to identify the location of interfering emitters in the cellular band and locations of high system usage. An antenna array and receiver/processor installed at cell sites yield a typical bearing accuracy of 3-5 degrees, resulting in location accuracy of approximately 500 ft. A vehicle-mounted radio direction finding unit is used to determine the exact location of the caller. The cost of base station equipment is estimated at $7,500 per site.

Systems Based on External Location Network

- **Terrapin Corporation** is the developer of the PINS system, which computes the location of the caller by tracking signals from commercial FM radio stations. The patented PINS system measures the phase of the FM pilot tone from three or more stations and, based on these measurements, computes the range or distance to each transmitter. Location of the caller is computed by triangulation. Terrapin reports that typical system accuracy is 20-30 meters. Terrapin plans to have PINS chipsets embedded in wireless phones at an estimated cost of $35 per phone. The company claims that FM signals provide a high level of in-building penetration.

- **NAVSYS Corporation** has developed the TIDGET Mayday System which computes the caller's location using a modified GPS receiver and modem interfaced to a mobile phone. The TIDGET receiver "takes a snapshot" of the captured GPS signals and transmits the data to the NAVSYS Operations Center where location is computed. The caller's location is passed to the responsible PSAP. Typical accuracy of the TIDGET Mayday System is 100 meters. NAVSYS expects TIDGET sensor prices to drop to under $50 within one year for large quantity purchases.

- **Smith Advanced Technology, Inc.** offers the RALI system for mobile 9-1-1 location and related applications. RALI units incorporate a GPS receiver, microcontroller and software. The company reports that RALI units designed as a retrofit to existing cellular phones will be available in late 1994 at an estimated price of $300. Smith

expects RALI units to be embedded in mobile phones within a year at an incremental cost of under $100. The company also offers a RALI PSAP unit designed to integrate the RALI system into the PSAP's operations.

- **Galaxy Microsystems, Inc.** has developed a ground wave system which computes location based on transmissions from four towers located on the periphery of a metropolitan area. Galaxy receivers, which could be embedded in a wireless phone, compute location based on Time-Difference-of-Arrival (TDOA) measurements. System accuracy is reported to be 10 meters or better. Galaxy reports that the location network can be deployed around a metropolitan area for approximately $200,000. It is projected that a Galaxy receiver chipset for installation in wireless phones could be made available in large quantities for $15-$25.

- **Automatic Vehicle Monitoring** (AVM) systems operating in the 902-928 MHz band can compute the location of users in system coverage areas with a typical accuracy of 100-150 feet or better. These systems use spread spectrum transmissions to network base stations and compute location at a network control center using Time-Difference-of-Arrival measurements. Transceivers are typically vehicle mounted, though some companies are working on portable configurations. Current transceiver prices are on the order of $300. Current and prospective operators of AVM-band networks include AirTouch Teletrac, Pinpoint Communications, Inc., Southwestern Bell Mobile Systems and MobileVision, Inc. Only Teletrac has a commercially operational system today, with network coverage in six cities.

Terrapin Corporation
11958 Monarch Street
Garden Grove, CA 92641
Telephone: (714) 898-8200
Fax: (714) 895-7526

Company Background

Terrapin Corporation is a venture capital funded company which was formed in 1991. The company has developed and patented radiolocation technology which uses signals transmitted by commercial FM radio stations to compute location. The founders of the company have backgrounds in GPS receiver development, with companies such as Texas Instruments, and also have prior engineering experience with commercial FM networks. The Terrapin technology was developed on the premise that FM receiver technology is inherently low cost and FM signals will provide superior performance to GPS in urban environments and can be tracked indoors.

Terrapin Corporation is affiliated with KOR Electronics, a supplier of radar simulation and electronic countermeasure equipment. The two companies have approximately 50 employees, mostly engineering and technical support staff.

Terrapin PINS System

The Terrapin system is referred to as PINS, which stands for Position, Information and Navigation System. The PINS system computes location by measuring the phase of the pilot tone sine wave broadcast by commercial FM transmitters. PINS algorithms convert phase measurements on signals from three or more stations to range measurements, and location is computed by triangulation.

For wireless 9-1-1 applications, a PINS receiver module is interfaced to the phone or embedded in the phone. The phase measurement data will be transmitted over the wireless network to a processor at the PSAP or other site where location will be computed. This will minimize receiver cost. For some other applications, location will be computed in the phone.

The Terrapin system requires installation of a Fixed Observer in each metropolitan area. The Fixed Observer computes phase and frequency drift corrections for each station, effectively synchronizing the transmissions off-line. The corrections are transmitted to users over an FM subcarrier or other suitable broadcast medium.

Terrapin believes that a major advantage of the PINS system is its use of the existing infrastructure of some 4,000 commercial FM radio transmitters operating in the U.S., many of which broadcast at a power level of 50,000 watts or more. According to

Terrapin, use of commercial FM transmissions eliminates the need for network infrastructure and provides for good urban and in-building performance.

Target Applications

Intended applications for the Terrapin PINS system include mobile 9-1-1, roadside assistance, stolen vehicle recovery, routing travellers to their destination, fleet management and electronic monitoring of probationed and parolled prisoners.

System Status

The Terrapin system has been in development since 1991 and live system demonstrations have been conducted since 1992. The current receiver test hardware configuration is PC-based. The first PINS receiver product, a single printed circuit board in an enclosure, is scheduled to be available in September. Terrapin management reports that within the next six months the company will complete the development of a PINS receiver in the form of a low cost chipset suitable for incorporation into wireless phones.

Terrapin is currently establishing alliances with wireless network operators and other potential partners who will work with Terrapin to commercialize the PINS technology for targeted applications. Terrapin is also seeking alliances with major cellular phone manufacturers who will incorporate the PINS location technology into their phones. The Terrapin system will be commercially available in a number of major cities, beginning in 1995.

System Accuracy

Terrapin states that the accuracy of the PINS system, for mobile 9-1-1 applications, will typically be 20-30 meters, depending on the multipath environment. PINS receiver configurations will vary somewhat depending on the performance and cost level required for the application.

Performance in Dense Urban Environments

Terrapin Corporation claims that the system performs well in urban environments since the FM signals tracked by PINS are relatively low in frequency and not subject to shadowing from tall buildings and foliage. PINS algorithms are designed to optimize performance in high multipath environments.

In-Building Penetration and Vertical Resolution

Terrapin believes its radiolocation system has better in-building penetration than competing systems due to the use of relatively low frequency FM signals and due to the high power levels of commercial FM broadcast stations. Terrapin claims that signals from three or more FM stations can be received in most buildings and that location accuracy of 20-30 meters can generally be obtained.

The PINS system does not currently compute altitude. However, Terrapin is investigating ways to compute altitude using microcell repeaters.

Cost

Terrapin estimates that by sharing the processor in the wireless phone, PINS chipsets can be supplied to cellular phone manufacturers and other partners for approximately $35 per chipset. Terrapin plans to license PINS technology to wireless phone manufacturers.

The cost to deploy redundant Fixed Observers in major metropolitan areas is estimated at $25,000 per city.

NAVSYS Corporation
14960 Woodcarver Road
Colorado Springs, CO 80921
Telephone: (719) 481-4877
Fax: (719) 481-4908

Company Background

NAVSYS Corporation, which was founded in 1986, is a privately-held research and development company that incorporates GPS technology into customer products. The company's activities are focused in the following areas:

Innovative Research: conducts basic and applied research in GPS-related areas under contract to government and industrial clients, emphasizing conceptual research and systems prototyping under Small Business Innovative Research (SBIR) and similar R&D contracts.

Technology Licensing: NAVSYS develops and patents GPS technology for license and transfer to companies serving commercial markets. The emphasis is on technology transfer for low end, low cost high volume markets such as weather balloons and vehicle tracking systems.

Special-Purpose Equipment: NAVSYS designs and manufacturers small quantities of special purpose, high end systems, equipment and software, including GPS signal generators, GPS translator test equipment and precision range.

NAVSYS Corporation has 24 employees and annual revenues of approximately $2 million.

TIDGET Mayday System

The TIDGET is low cost GPS sensor, developed and patented by NAVSYS, which is designed to "take a snapshot" of the raw sampled data from GPS satellite transmissions. The TIDGET does not include the Digital Signal Processor and microcomputer included in standard GPS receivers which, according to NAVSYS, significantly reduces the cost. The TIDGET receiver is embedded in the GPS antenna module which is mounted in a suitable location on (or inside) the vehicle for maximum visibility of the sky. The current configuration of the TIDGET is designed for vehicular, rather than portable applications. However, NAVSYS reports that the company is currently developing a portable TIDGET configuration for downed pilot and other emergency applications under an ARPA contract.

The TIDGET sensor is integrated with the Mayday terminal installed in the vehicle which provides a two-way data link between the vehicle and the Operations Center. A modem

for communication over the selected communication network (cellular, PCS, ESMR or other) is included in the Mayday terminal.

NAVSYS reports that the TIDGET is able to turn on, capture and transmit satellite data in less than one second. Computation of location at the Operations Center also requires less than one second. With a 9600 baud modem, or faster, the process of locating the caller typically requires no more than 3 seconds.

The TIDGET does not process the GPS data, but rather transmits it over a communication link (cellular, PCS, ESMR or other) to the Operations Center, where the data is processed and location computed. The Operations Center also places priorities on calls, routes calls for assistance to the appropriate agency and notifies the motorist of the action taken and the anticipated response time. The initial Operations Center will be located in Denver, Colorado. A single Operations Center can cover a large geographic area.

The TIDGET will be manufactured under license by companies such as Plessey.

Target Applications -

Civil applications for the TIDGET include 9-1-1 (Mayday) and other personal location services. Government applications for the TIDGET include tracking weather sensors (radiosondes), drifting bouys carrying oceanographic sensors, sonobouys and wildlife tracking.

System Status

The TIDGET was initially developed by NAVSYS in 1990. In 1992, NAVSYS received experimental contracts for the TIDGET from the U.S. Air Force for tracking radiosondes and from the Royal Aircraft Establishment for tracking sonobouys.

NAVSYS Corporation will participate in an operational test of a vehicle Mayday service, sponsored by the Federal Highway Administration (FHWA). Along with NAVSYS, team members involved in the test include Enterprise, a multi-state IVHS research and implementation organization, Comnet Cellular, U.S. West, Cellular One, Environmental Systems Research Institute, the Colorado State Patrol and Castle Rock Consultants. The full-scale operational test, which will commence in mid-1995, will involve a minimum of 2,000 vehicles and will cover 12,000 square miles in Colorado. Each participating vehicle will be equipped with a TIDGET interfaced to a cellular phone. Among the primary purposes of the test is to implement and evaluate a low cost personal security system for obtaining roadside assistance via an automated system that provides the responding party with detailed information on the location and type of assistance required.

Plessey is licensed to manufacture the TIDGET. Production configurations of the TIDGET are expected to be available from Plessey in early 1995.

System Accuracy

The TIDGET Mayday System is designed to provide approximately 100 meter accuracy. NAVSYS reports that accuracy of up to 10 meters can be obtained if additional satellite data is transmitted and more time is allowed to compute location.

Performance in Dense Urban Environments

The TIDGET Mayday System is designed to compute location, in some cases, with as few as two visible satellites. NAVSYS states that this provides the capability to compute location in dense urban areas a higher percentage of the time than standard GPS receivers which require 3-4 visible satellites.

In-Building Penetration and Vertical Resolution

The GPS system does not provide for in-building penetration. An unobstructed view of the satellites is required.

Cost

NAVSYS states that the TIDGET currently costs less than $100 per unit which is significantly less than the cost of a conventional GPS receiver. The company states that TIDGET sensor prices are projected to drop to less than $50 within a year for large quantity purchases.

Smith Advanced Technology, Inc.
2009 Gallatin Street
Huntsville, AL 35801
Telephone: (205) 533-3822
Fax: (205) 534-7461

Non Aerospace

Company Background

Smith Advanced Technology, Inc. is a privately-held company which was formed in 1985. The company is primarily active in the development of software products and systems for government agencies and the military. Smith is involved in verification and validation of software for control of the Space Shuttle's main engine system. The company is also focusing its capabilities in artificial intelligence systems at reducing manpower requirements at traffic management centers. The company's annual sales were not disclosed.

Roving Automatic Location Identification System

The Roving Automatic Location Identification System (RALI), developed by Smith Advanced Technology, provides the PSAP call-taker with the location and call-back telephone number of the wireless caller. The system uses the same channel to transmit location and caller number (ANI) and for voice conversation between the caller and the PSAP. RALI uses the Global Positioning System (GPS) to compute the location of the caller.

The RALI in-vehicle unit consists of a GPS receiver, a microcontroller, software logic and appropriate telephone interfacing electronics. When 9-1-1 is dialed, the RALI unit responds to a request from the PSAP for current position, speed, direction and call-back telephone number. The protocol provides for privacy protection so that vehicle ID and location is only provided as authorized.

RALI offers a retrofit kit to accommodate the currently installed base of mobile telephones. The PSAP portion of the RALI system requires a 486DX or equivalent processor. The RALI system will operate on any wireless network.

Target Applications

Applications for the RALI system include mobile 9-1-1, roadside assistance, fleet management, emergency notification for the hearing and speech impaired and other consumer and commercial applications.

System Status

Smith Advanced Technology reports that field testing of the RALI system commenced in early 1994. Field trials have been conducted in Atlanta, Las Vegas, Huntsville and Mobile, Alabama, and other locations. The company states that a Canadian wireline/cellular operator will install the RALI system at 9 PSAPs and will market the retrofit unit in a Canadian province beginning late this year.

Smith is establishing alliances with wireless and wireline operators in the U.S. who will market RALI for commercial and consumer applications. The company hopes to work with wireless phone manufacturers to have RALI units embedded in the phone.

The company plans to commence product delivery in late 1994.

System Accuracy

The accuracy of GPS is specified by the U.S. government as 100 meters. GPS performance can be degraded in dense urban environments by signal blockage from buildings, though Smith Advanced Technology claims that current GPS technology incorporated in the RALI system minimizes this problem. The company plans to offer low cost dead reckoning sensors as a future option.

In-Building Penetration and Vertical Resolution

The GPS system does not provide for in-building penetration. In portable phone applications, the system will save the last known position before the caller entered the building. If PCS base stations are installed inside buildings, the RALI system will receive/transmit the location of the building's base station or the base station on the individual floor.

Cost

The cost of the RALI mobile retrofit unit is approximately $300. Smith Advanced Technology expects to have RALI units embedded within mobile phones. The RALI unit in the phone will consist of a GPS receiver and software which would run on the phone's processor. The company states that the cost of embedded RALI units will be driven by GPS receiver costs which, depending on volume, could be under $100 in less than a year.